US009190774B2

(12) **United States Patent**
De Bruijn et al.

(10) **Patent No.: US 9,190,774 B2**
(45) **Date of Patent: Nov. 17, 2015**

(54) **CONTACT PIN, HEADER CONNECTOR AND CONNECTOR ASSEMBLY**

(75) Inventors: **Jeroen De Bruijn**, Loon op Zand (NL); **Gert Droesbeke**, Saint-Vit (FR); **Winnie Heyvaert**, Brasschaat (BE); **Ludwig Lange**, Nuland (NL); **Stefaan Hendrik Jozef Sercu**, Brasschaat (BE)

(73) Assignee: **FCI**, Guyancourt (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 194 days.

(21) Appl. No.: **13/994,163**

(22) PCT Filed: **Dec. 15, 2011**

(86) PCT No.: **PCT/IB2011/003240**

§ 371 (c)(1),
(2), (4) Date: **Sep. 3, 2013**

(87) PCT Pub. No.: **WO2012/080839**

PCT Pub. Date: **Jun. 21, 2012**

(65) **Prior Publication Data**

US 2013/0344743 A1 Dec. 26, 2013

(30) **Foreign Application Priority Data**

Dec. 16, 2010 (WO) PCT/IB2010/003522

(51) **Int. Cl.**

H01R 13/04	(2006.01)
H01R 13/627	(2006.01)
H01R 13/6471	(2011.01)
H01R 43/00	(2006.01)
H01R 43/16	(2006.01)

(52) **U.S. Cl.**

CPC ***H01R 13/6278*** (2013.01); ***H01R 13/04*** (2013.01); ***H01R 13/6471*** (2013.01); ***H01R 43/00*** (2013.01); *H01R 43/16* (2013.01); *Y10T 29/49204* (2015.01)

(58) **Field of Classification Search**

CPC H01L 2924/00013; H01L 2924/0002; H01L 2924/00; H01L 2224/29099; H01L 2924/00014; H01L 2924/3011; H01L 2224/2929; H01R 13/62905; H01R 13/62927; H01R 13/62966; H01R 13/62972; H01R 13/633; H01R 13/635

USPC 439/825, 82, 751, 682, 884, 943

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,681,392	A *	7/1987	Terita	439/751
6,260,268	B1	7/2001	Gentry	29/874
6,808,420	B2 *	10/2004	Whiteman et al.	439/607.08
2003/0040227	A1 *	2/2003	Norris	439/751
2006/0276081	A1	12/2006	Cohen et al.	439/608

FOREIGN PATENT DOCUMENTS

DE	10 2008 004 882 A1	7/2009
DE	20 2009 009 933 U1	10/2009
DE	20 2009 010 426 U1	11/2009

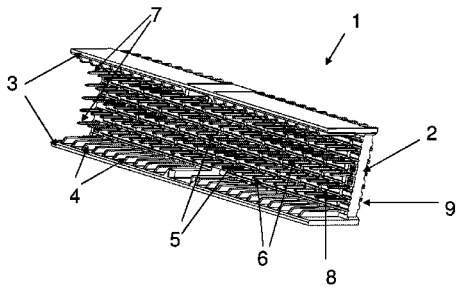
(Continued)

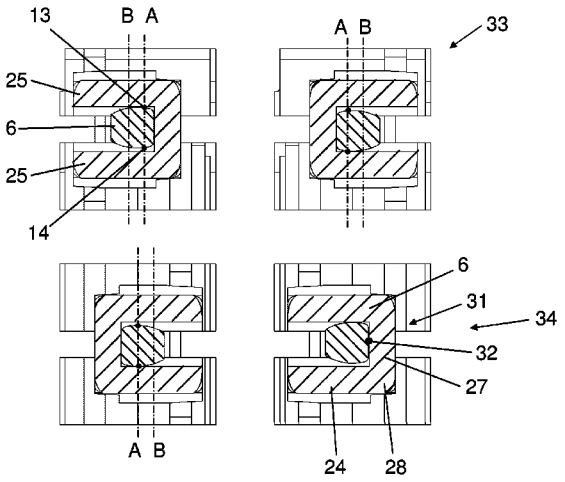
Primary Examiner — Abdullah Riyami
Assistant Examiner — Nelson R Burgos-Guntin
(74) *Attorney, Agent, or Firm* — Harrington & Smith

(57) **ABSTRACT**

The invention relates to a contact pin having longitudinal surfaces bulged to define opposite contact lines extending in longitudinal direction of the contact pin, wherein in cross section of the contact pin the plane through the two opposite contact lines is offset from the cross sectional center of the contact pin.

15 Claims, 8 Drawing Sheets





(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	0 077 941	A1	5/1983
EP	0 492 017	A1	7/1992
EP	1 049 201	A1	11/2000
EP	1 388 912	A1	2/2004
EP	2 099 098	A1	9/2009
GB	2 248 565	A	4/1992
GB	2 341 280	A	3/2000

* cited by examiner

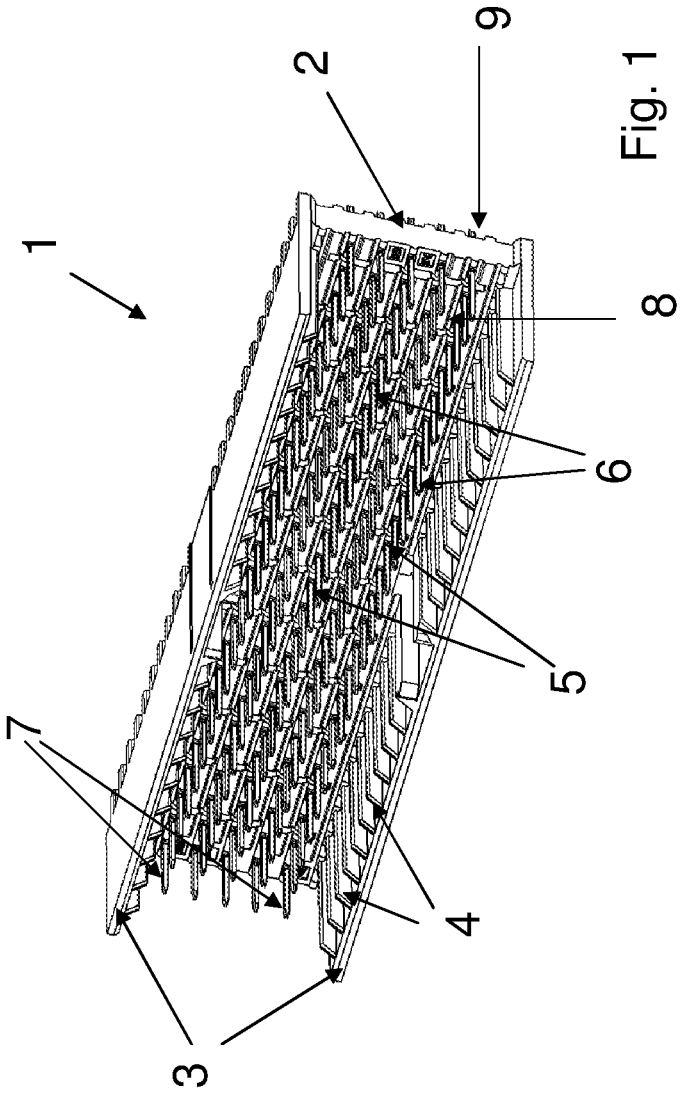


Fig. 1

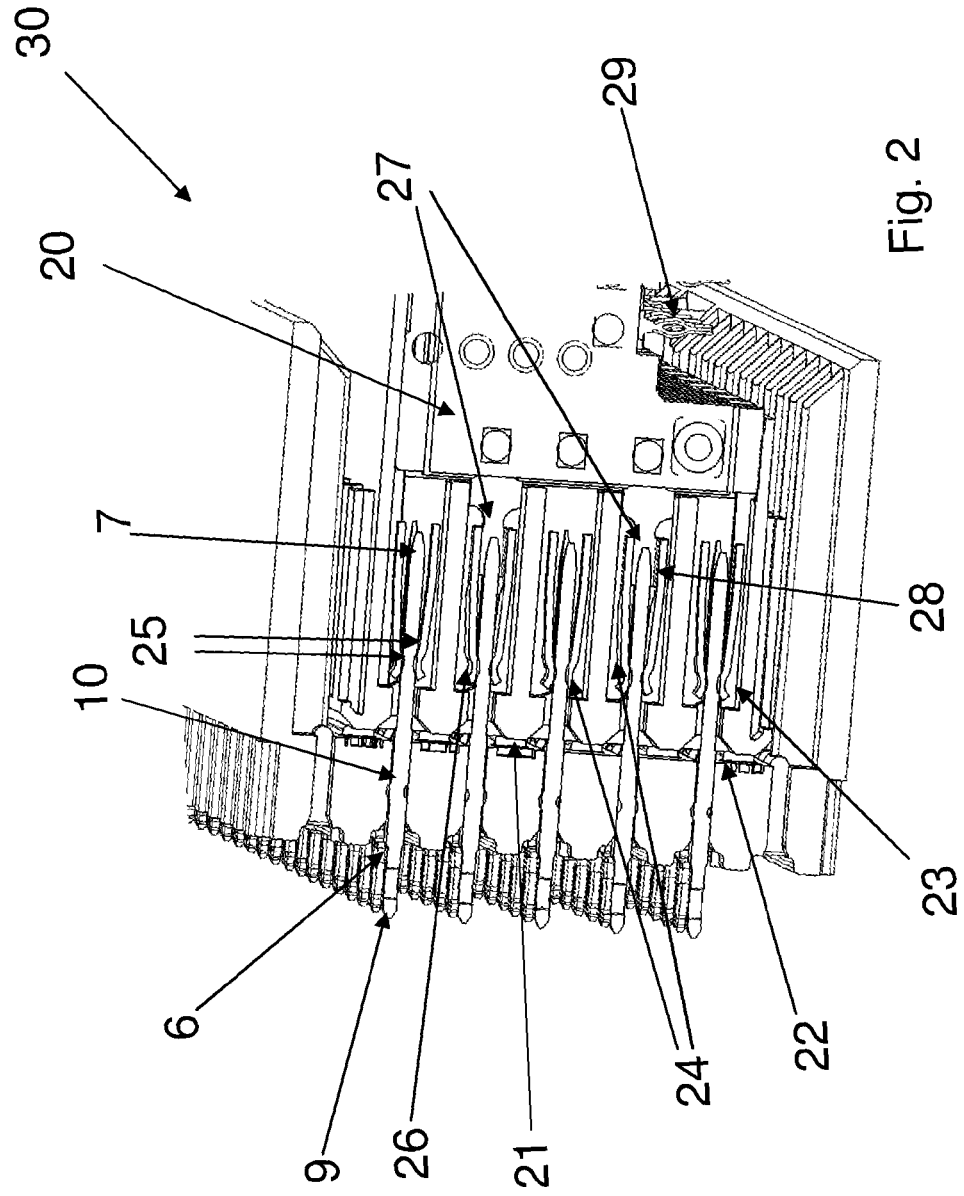


Fig. 2

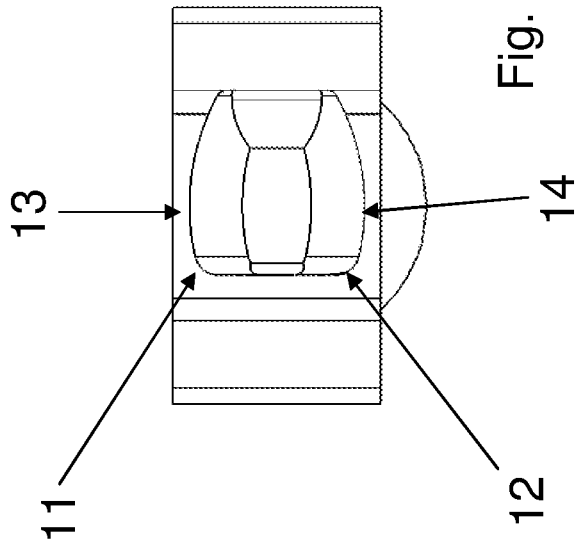


Fig. 3B

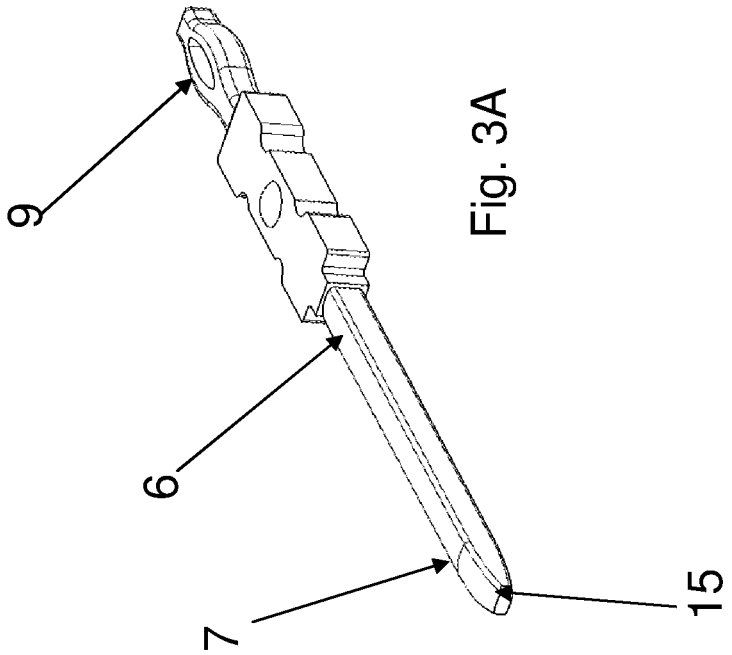


Fig. 3A

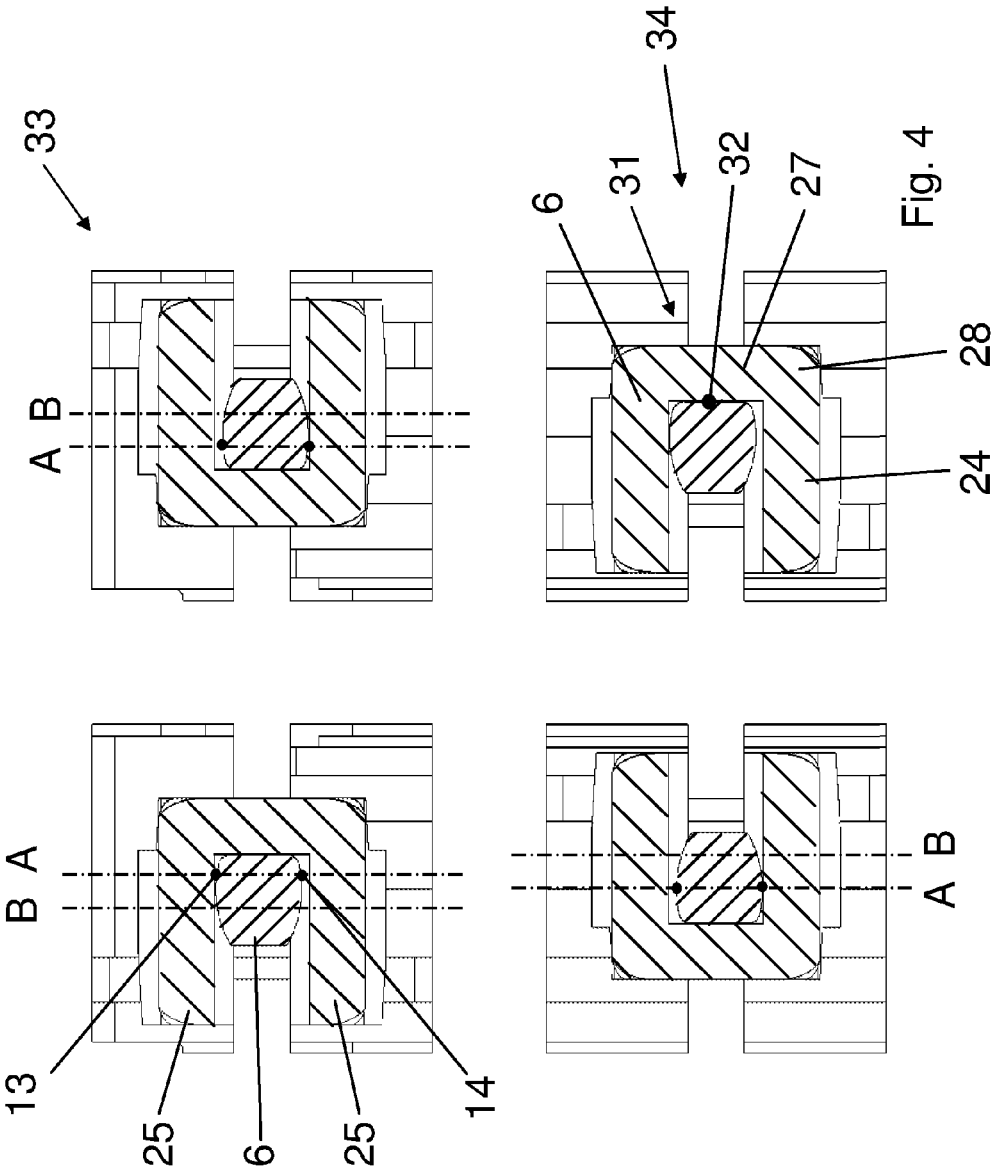


Fig. 4

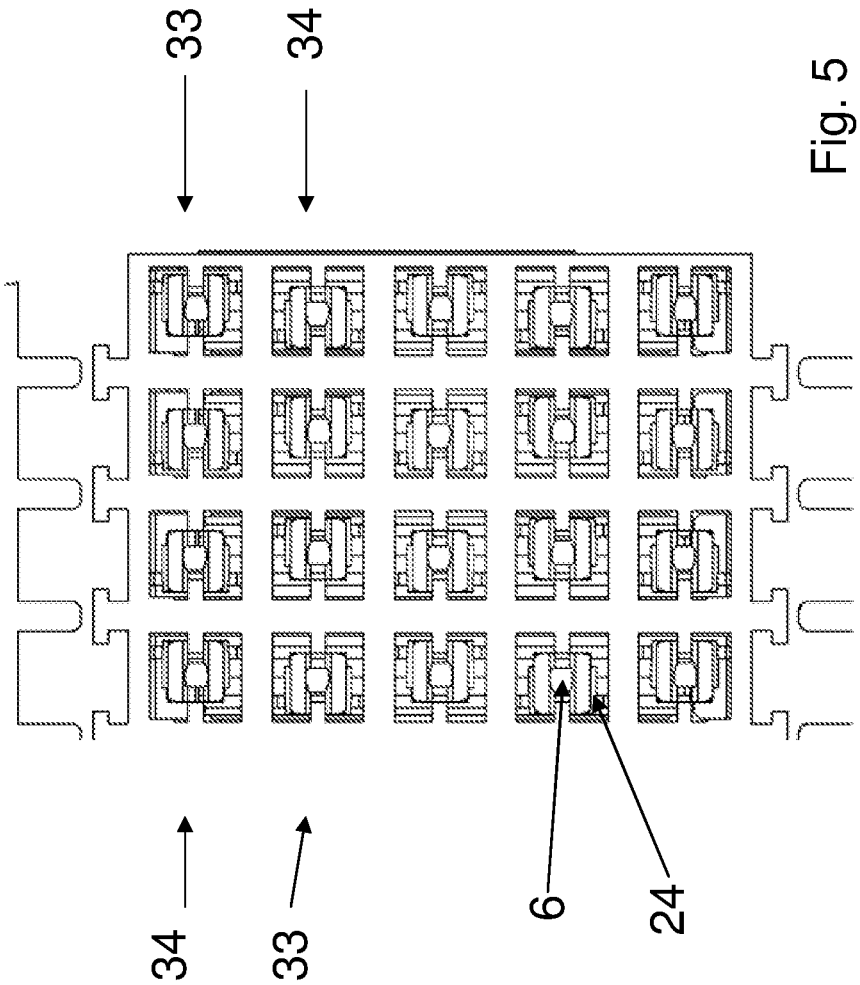


Fig. 5

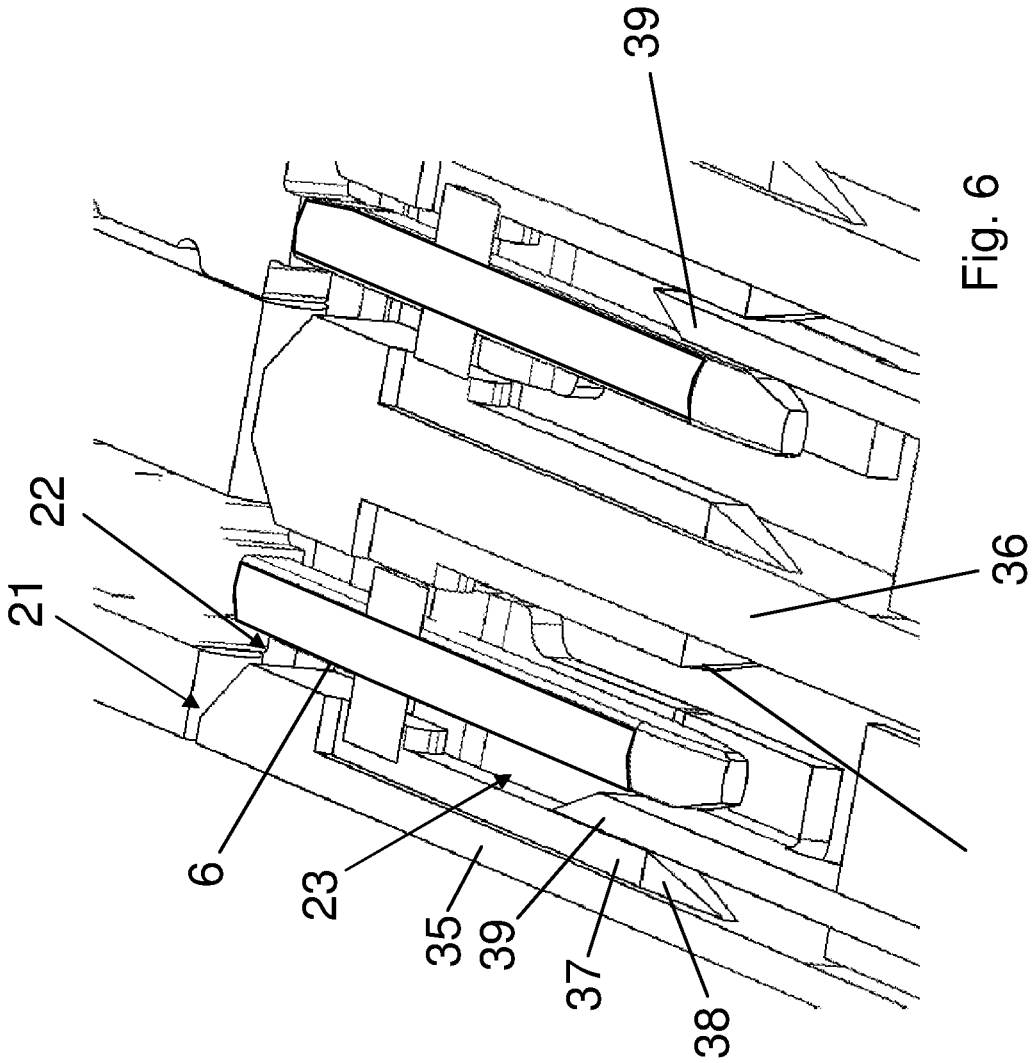


Fig. 6

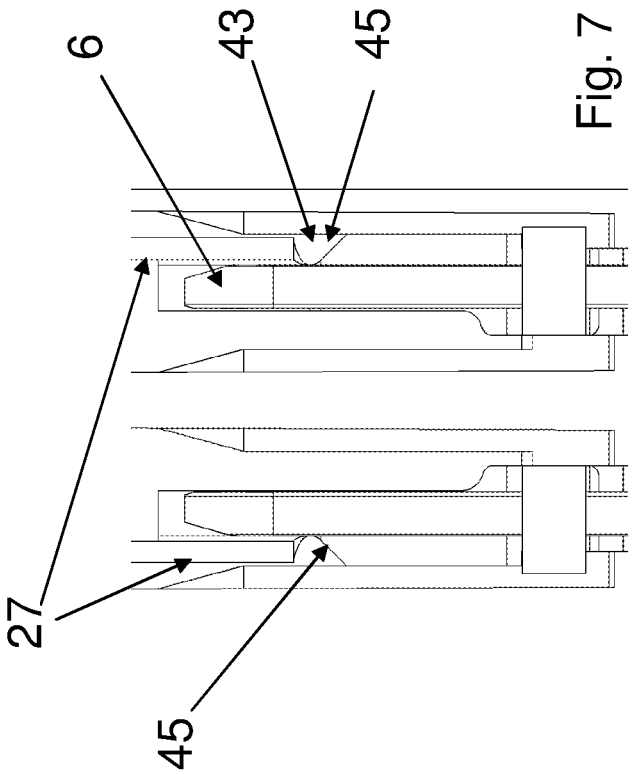


Fig. 7

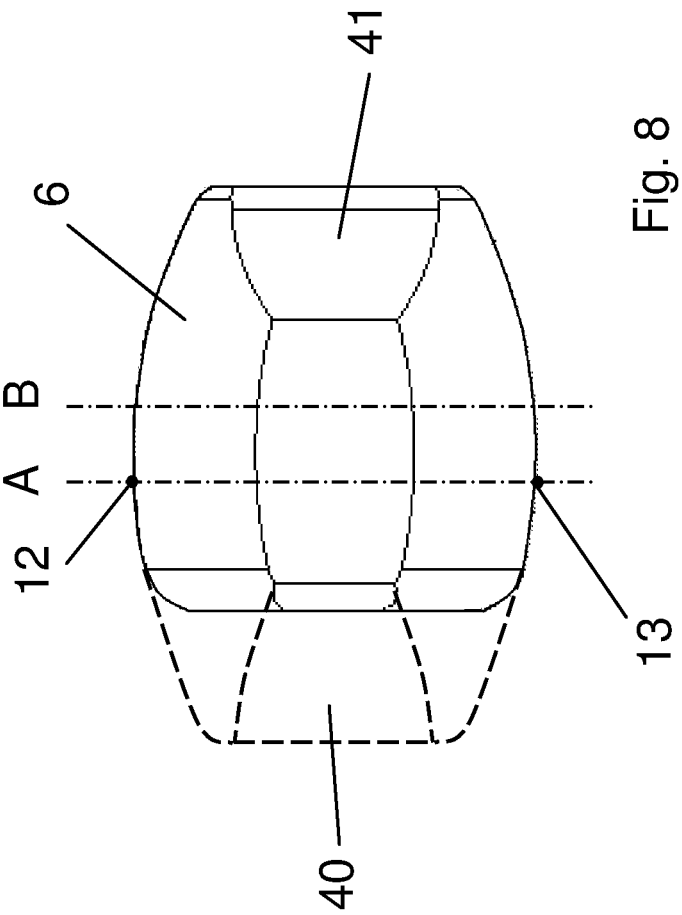


Fig. 8

CONTACT PIN, HEADER CONNECTOR AND CONNECTOR ASSEMBLY

TECHNICAL FIELD

The present disclosure relates to the field of electrical connector assemblies, to a header connector with one or more contact pins and to a contact pin for such header connectors.

BACKGROUND

With the increasing signalling speed required by present-day systems signals transmitted over a conductor become more and more sensitive to coupling and/or cross talk with neighbouring conductors. Such coupling and/or cross talk interaction between conductors is sensitive to the distance between the conductors. Thus, in order to accurately assess and/or control the amount and/or effect of such interaction on a particular conductor at one or more signal frequencies, the relative positions of the conductors are important.

The geometry of the conductors and their relative position also impacts the impedance of the system and the electric field. To optimize impedance, this impact should be minimized.

Furthermore, since there are continuing desires for miniaturization there is a need to provide connector designs which allow a compact build. Further concerns are cost reduction for materials and manufacturing.

SUMMARY

In a first aspect, the contact pin of claim **1** is provided. The asymmetric position of the contact lines make it possible to use it in combination with a receptacle contact having a U-shaped cross section, wherein the material of the contact pin is more concentrated between the contact lines and the walls of the U-shaped section. It has been found that pin material at the opposite side of the contact lines does not substantially contribute to signal transfer and therefore negatively affects crosstalk and impedance. Improved signal transfer and signal integrity are obtained without affecting mating stability and required insertion force.

In a second aspect a header connector according to claim **2** is provided. The header connector comprises at least one contact pin according to claim **1**, typically a plurality of pins arranged in an array or grid of rows and columns.

Impedance can be further improved by a connector according to claim **3**.

In a further aspect a connector assembly according to claim **4** is provided with a header connector and a corresponding receptacle connector. The contacts of the receptacle connector and/or the header connector can for instance have opposite terminal ends for mounting on or in a circuit board. Thus, the terminal end can be a "eye-of-the-needle" press fit contacts type or a "surface mount" contact type. The connector assembly may, e.g., be a straight connector, a mezzanine connector, or have an angle between opposite contacts, e.g., a right angle.

In a connector according to claim **5** the contact pin is substantially surrounded by the U-shaped portion of the receptacle contact. This further reduces cross-talk effects and improves impedance by reducing local distortions of electric field lines, which could otherwise be caused by a portion of the relatively narrow and sharp contact pin protruding from the relatively bulky and rounded-off receptacle contact.

Signal transfer and integrity can be further improved with a connector assembly according to claim **6**.

A connector according to claim **7** makes use of differential pair technology, which reduces crosstalk and electromagnetic interference, noise emission and noise acceptance. Moreover, it can achieve a constant and known characteristic impedance, allowing impedance matching techniques important in a high-speed signal transmission line or high quality balanced line and balanced circuit audio signal path.

Differential pair technology is further optimized in a connector assembly according to claim **8** or **9**. Notwithstanding the different orientation of the contact pins and the receptacle contacts in the ground contacts and signal pairs, the contact lines of these contacts are still coplanar in a connector assembly according to claim **11**. This contributes to optimization of the systems impedance.

A connector assembly according to claim **12** and/or **13** allows easier insertion of contact pins of any cross sectional geometry into a corresponding receptacle contact.

The contact pins can advantageously be manufactured in a method according to claim **14**, e.g., by punching or stamping. As an alternative, the contact pin may be stamped and the asymmetric bulge may be produced by coining at least a portion of the contact pin in an appropriate shape.

BRIEF DESCRIPTION OF THE DRAWINGS

These and further aspects will hereafter be more fully explained with reference to the drawings showing an embodiment of the invention by way of example.

FIG. **1**: shows in perspective view an embodiment of a header connector according to the invention;

FIG. **2**: shows in perspective cross section a connector assembly of a receptacle connector with the header connector of FIG. **1**;

FIG. **3**A: shows in perspective view a contact pin of the header connector of FIG. **1**;

FIG. **3**B; shows the contact pin of FIG. **3**A in front view;

FIG. **4**: shows a signal pair and a ground pair of the connector assembly of FIG. **2**;

FIG. **5**: shows a configuration of differential pairs of the connector assembly of FIG. **2**;

FIG. **6**: shows in perspective view a detail of the connector assembly of FIG. **2**;

FIG. **7**: shows a detail of an alternative embodiment of a connector assembly according to the invention;

FIG. **8**: shows in front view two stages of manufacturing of the contact pin of FIGS. **3**A and **3**B.

DETAILED DESCRIPTION OF EMBODIMENTS

FIG. **1** shows a header connector **1** comprising a base plate **2** and two sidewalls **3** reinforced by ribs **4**. The base plate **2** is provided with a grid-like array of columns and rows of contact openings **5** each accommodating a contact pin **6**. A contact pin **6** is shown in more detail in FIG. **3**. The contact pins **6** comprise a first terminal end **7** extending from a mating surface **8** for cooperation with a receptacle contact described hereinafter, and a second terminal end **9** which in the shown embodiment is an eye-of-the-needle press fit contact for circuit board mounting. Between the two terminal ends **7**, **9** the contact pin **6** comprises a profiled middle section **10** moulded into the base plate **2**. As shown in more detail in FIGS. **3**A and **3**B, the contact pins **6** have two opposite contact faces **11**, **12** bulging to form contact lines **13**, **14** indicated by an interrupted line in the drawing of FIG. **3**A. To allow easier insertion of the contact pin **6** into a receptacle the first terminal end **7** comprises a tapered outer end **15** which gradually narrows down.

In FIG. **2** the header connector **1** is shown in perspective cross section, while the header connector **1** is in mating contact with a receptacle connector **20**. The receptacle connector **20** comprises a housing with a mating face **21** and openings **22** each allowing access to a cavity **23** accommodating a receptacle contact **24**. The receptacle contacts **24** each comprise two resilient contact beams **25** slightly inclining towards each other in the direction of the openings **21**. The outer ends **26** of the beams **25** close to the opening **21** are curved towards each other to provide a tight resilient grip for an inserted contact pin. The other ends of the beams **25** are bridged by a back **27** to form a U-shaped section **28**. The back **27** extends in a direction opposite to the beams **25** towards a second terminal end **29**. Such receptacle contacts may for instance be manufactured by stamping or punching a blank and bending, possibly also including a coining step. In the embodiment shown in the drawings the terminal end **29** is under right angles with the contact beams **25** and is shaped as an eye-of-the-needle press fit contact for circuit board mounting. This way the receptacle connector **20** and the header connector **1** form a connector assembly **30** for connecting two circuit boards under right angles. In alternative embodiments different angles are conceivable.

FIG. **4** shows a group of four contact pins **6** inserted in four respective receptacle contacts **24**. In the drawing line A represents the plane through the contact lines **13**, **14**, whereas line B represents a vertical plane through the center line of the receptacle contact **24**. Plane A through the contact lines **13**, **14** is located between the vertical center face B of the contact pin **6** and the back **27** of the U-shaped section **28** of the receptacle contact **24**.

The contact pins **6** have a side face **31** facing the back **27** of the U-shaped section **28** of the receptacle contact **24**. The side face **31** bulges towards the back **27** to form a third contact line **32**. Here the width of the contact beams **25** is about two times larger than the width of the contact pin **6**.

The contacts **6**, **24** in FIG. **4** are arranged to form a differential signal pair **33** and a pair **34** of ground contacts. With the signal pair **33** the backs **27** of the respective receptacle contacts **24** are turned towards each other so the distance between the conductive parts of the contacts **6**, **24** is minimized. The backs **27** of the respective receptacle contacts **24** of the ground pair **34** are turned away from each other. The orientation of the corresponding contact pins **6** alternates correspondingly, so the face A through the contact lines **13**, **14** is always between the back **27** and the vertical center face B of the contact pin **6**. The contact pins **6** and the thickness of the back **27** are configured in such a way that the contact lines **13**, **14** of the signal pairs **33** in a column are always coplanar with the contact lines **13**, **14** of the ground pairs **34** and the other signal pairs **33**. In each column and row of the connector assembly signal pairs **33** and ground pairs **34** are arranged in an alternating pattern, as shown in FIG. **5**. This way each signal pair **33** is effectively shielded by surrounding ground pairs **34**. Within the columns the contact lines **13**, **14** of all contact pins **6** are coplanar, whereas the cross sectional centre of the contact pins **6** is alternatingly at the left side or at the right side from the contact lines **13**, **14**.

As shown in FIG. **6**, each cavity **23** in the receptacle connector **20** is provided with side walls **35**, **36** with a rib extending in a direction parallel to the longitudinal direction of the cavity **23**. The rib **37** comprises a lead-in portion **38**. The rib **37** serves to establish the position of the contact beams **25** within the cavity **23** and to keep the contact beams **25** separated from the side walls **35**, **36**. To allow easier insertion of the contact pin **6** the back **27** of the U-shaped section **28** of the receptacle contact **24** comprises an inwardly chamfered edge **39** directed towards the opening **22** in the mating surface **21**.

To allow easier insertion further, or alternatively, a protruding portion **43** is provided at the side wall of the cavity, as shown in FIG. **7**. The protruding portion **43** is arranged in front the back **27** of the receptacle contacts **24** towards the receptacle mating surface **21**. The portion **43** comprises an inwardly chamfered edge **45** directed towards the opening **22** in the mating surface **21** and overlapping at least part of the back **27** of the respective receptacle contacts **24**.

FIG. **8** shows a method for manufacturing a contact pin **6**. The tip of the contact pin **6** is shown in front view. The contact pin **6** can be manufactured by first manufacturing a regular symmetrical pin having the contact lines **13**, **14** in its vertical center plane. In a next step a portion **40** of the pin can be removed along a cutting plane parallel but offset to the plane A through the contact lines **13**, **14**. In the drawing of FIG. **8** the portion **40** is indicated by dotted lines. The opposite side **41** remains intact. This way, the vertical center plane of the contact pin **6** is shifted towards intact side **41** and the plane A through the contact lines **13**, **14** becomes offset from the new vertical center plane B.

The invention claimed is:

1. Contact pin having longitudinal surfaces bulged to define opposite contact lines extending in longitudinal direction of the contact pin, wherein a material of the contact pin extends between the bulged longitudinal surfaces without a gap therebetween, and wherein in cross section of the contact pin the plane through the two opposite contact lines is offset from the cross sectional centre of the contact pin.

2. A header connector comprising a housing and one or more contact pins, the one or more contact pins having longitudinal surfaces bulged to define opposite contact lines extending in longitudinal direction of the contact pin, wherein a material of the contact in extends between the bulged longitudinal surfaces without a gap therebetween, and wherein the plane through the two opposite contact lines is offset from the cross sectional centre of the contact pin.

3. The header connector according to claim **2** comprising at least one column of contact pins wherein the contact lines of at least a part of the contact pins are coplanar.

4. A connector assembly comprising a receptacle connector and a header connector, wherein the receptacle connector comprises a mating surface with openings allowing access to receptacle contacts, wherein each receptacle contact has resilient contact beams having free ends near the respective opening, the opposite ends being bridged by a back to form a U-shaped cross section; and wherein the header connector comprises contact pins, having longitudinal surfaces bulged to define opposite contact lines extending in longitudinal direction of the contact pin, wherein a material of the contact pin extends between the bulged longitudinal surfaces without therebetween, and wherein in cross section of the contact pin the plane through the two opposite contact lines is between the cross sectional centre of the contact pin and the back of the receptacle contact.

5. The connector assembly according to claim **4** wherein the contact beams of the one or more receptacle contacts have a width which is larger than the width of the one or more contact pins.

6. The connector according to claim **4** wherein at least a part of the contact pins are shaped to form a third contact line contacting the back of the receptacle contact.

7. The connector assembly according to claim **4** wherein the contact pins of the header connector and the receptacle contacts of the receptacle connector are arranged to form one or more differential pairs wherein in each pair the contact pin

and receptacle contact of one contact mirrors the contact pin and receptacle contact of the other contact.

8. The connector assembly according to claim **7** wherein the differential pairs contain signal pairs having the two receptacle contacts arranged back-to-back, shielded by ground pairs comprising two receptacle contacts arranged with the contact beams pointing to each other in cross section.

9. The connector assembly according to claim **8** comprising rows and columns of alternating ground and signal pairs.

10. The connector assembly according to claim **8** wherein the contact lines of the contact pins and the back of the receptacle contact are configured in such a way that the contact lines of the signal pairs in a column are coplanar with the contact lines of the ground pairs in the column.

11. The connector assembly according to claim **4** wherein the back of at least a part of the receptacle contacts comprises an inwardly chamfered edge directed towards the receptacle mating surface.

12. The connector assembly according to claim **4** wherein the housing comprises a portion arranged in front of at least a part of the receptacle contacts towards the receptacle mating surface, comprising an inwardly chamfered edge directed towards the receptacle mating surface and overlapping at least part of the back of the respective receptacle contacts.

13. Method of manufacturing a contact pin according to claim **1** wherein the contact pin is first provided with a symmetrical cross section and subsequently a side part of the contact pin is removed along a cutting plane parallel to the plane through the contact lines.

14. The contact pin according to claim **1** wherein the contact pin further comprises a side face, wherein the side face is configured to bulge to form a third contact line.

15. The connector according to claim **4** wherein each on the contact pins further comprise a side face, wherein the side face is configured to bulge to form a third contact line contacting the back of the receptacle contact.

* * * * *